Draft Internal Assessment Resource
For planning purposes only

Draft standard Physics 2.1: Carry out a practical physics investigation that leads to a non-linear mathematical relationship

Resource reference: Physics 2.1B

Resource title: Portfolio of Practical Reports

Credits: 4

Teacher guidelines

The following guidelines are designed to ensure that teachers can carry out valid and consistent assessment using this internal assessment resource.

Teachers need to be very familiar with the outcome being assessed by Achievement Standard Physics 2.1. The achievement criteria and the explanatory notes contain information, definitions, and requirements that are crucial when interpreting the standard and assessing students against it.

Context/setting

This activity is not ready to use. It provides a clearly structured *framework* for assessing whether a student's skills and understanding meet the specified standard, *and suggestions of contexts* that might be appropriate, and an *assessment schedule*. Before using it, you will need to select or negotiate the contexts that will engage your students, work out exactly how the framework will be applied to these contexts, create or finalise any student pages that are needed, and ensure that the assessment schedule aligns with the activity in its final form.

This assessment requires students to create a portfolio consisting of a series of experiments that require students to take measurements, use techniques to maximise accuracy, analyse the collected data, and develop the equation that models a non-linear physical relationship. Students record and graph data, transform the graph, use the transformed graph to find the mathematical equation, and produce a report which evaluates and explains the results.

Suitable relationships might include square, square root, inverse and inverse square relationships. The sample context for this assessment is the relationship between length of a pendulum and time taken for one oscillation.

Additional possible contexts include:

- Relationship between the length of a pendulum and the time period.
- Relationship between image distance and focal length for a convex lens.
- Relationship between mass and period for a spring-mass system.
- Relationship between the length of a pendulum and the time period.
- Relationship between terminal velocity and number of paper muffin cups when dropping stacks of paper muffin cups.
- Relationship between current drawn from a power supply and the resistance of the circuit.

Conditions

- At least five investigations that lead to a non-linear relationship should be carried out.
- Gathering of the evidence for this standard will take place over the year.

Select an appropriate range of contexts based on equipment availability and the potential to generate an adequate set of data to meet the standard. The contexts could also be student generated, subject to your approval. For a specific context, provide students with the appropriate theoretical equation as shown in the additional information section of the Student Instructions.

The investigations are to be performed in-class under supervised conditions; each student should gather and evaluate their own set of data, and produce their report independently. No material is to be taken from the laboratory. If apparatus is limited, students may pursue other activities until equipment is available, as opposed to working in groups.

Determine the time required, as time will depend on the nature of the relationship and context; a continuous period is recommended for each task.

Conclusions must be written; confirm the format of the report with your students. The format could be, but is not limited to, a written report, computer presentation software or web page.

Analysis can be done manually, via graphing calculator, or via a computer, but the analysis must be able to be stored by the assessor or printed for marking purposes.

The assessment schedule provided is for an individual report. Adapt the generic version of the task and schedule as necessary for each individual experiment. The student's overall portfolio grade is that which has been achieved in at least four different reports. Replacement evidence can be used from any other report if the evidence from four reports falls slightly short of the required quantity of evidence.

Resource requirements

Resources will depend on the relationship investigated. Resources for the sample pendulum context should include:

- pendulum bob
- two halves of cork
- stop watch
- retort stand
- clamp arm and boss head
- string.

Additional information

These assessment contexts could be used as a single assessment or as part of a series.

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Achievement	Achievement with Merit	Achievement with Excellence
Carry out a practical physics investigation that leads to a non-linear mathematical relationship.	Carry out an in-depth practical physics investigation that leads to a non-linear mathematical relationship.	Carry out a comprehensive practical physics investigation that leads to a non-linear mathematical relationship.

Student instructions

Introduction

This task is one of <insert number> investigations that you will be carrying out over <insert time period> which will form a portfolio of investigations and reports. Your final portfolio grade will be the grad that has been achieved in at least four <insert number here if different> different reports.

<Insert context and background to experiment, example for a pendulum is supplied below> James and Matthew recently visited Pisa in Italy. Whilst they were there, they learnt about a famous Italian scientist, Galileo. Galileo was a medical student at the University of Pisa during the Sixteenth century. Galileo knew that the speed of a patient's pulse was a useful guide to how ill they were, however, doctors of that era were unable to consistently measure the pulse. At that time, there was no accurate way to measure small time intervals, for example, seconds or parts of seconds. Furthermore, it is no good comparing someone's pulse with that of a healthy person because pulses can vary a lot.

Galileo noticed lamps swinging from the roof in the cathedral in Pisa. He got the idea of using a swinging weight as a timer. The swinging weight was called a pendulum. It became the first way to measure small time intervals accurately.

When James and Matthew returned to school, they wanted to find out more about the physics of pendulums. In order to use the pendulum to measure time, they needed to find out the relationship between the length, L, of a pendulum and period, T (the time it takes to complete one full swing).

In this activity, you will perform the investigation for James and Matthew using a model, and prepare a report describing the relationship between the length, L, of a pendulum and period, T. Your model will consist of a simple small pendulum made from a string and a bob.

Task

Working **independently**, you will be given a period of <insert time> to collect data, carry out the analysis of the data and write a report. The report should be handed in at the end of the assessment period. Confirm the format of the report with your teacher, for example, a written report or computer presentation. No material is to be taken from the laboratory.

Gathering information

Using the equipment provided by your teacher set up <insert the experimental setup>. Investigate the relationship between the <insert independent variable>, and <insert dependent variable>.

As you gather information, you should:

- identify the dependent and independent variables in the investigation
- identify any variables to be controlled
- record **all** raw measurements in an appropriately headed results table, using appropriate units and significant figures
- make sufficient measurements to allow you to draw a graph that will help you determine this relationship
- adjust your model or methods as necessary to maximise accuracy.

Data analysis

Plot an appropriate graph to explore the mathematical relationship between <insert relevant variables>. Include a curve of best fit (the raw data will not give a straight-line graph).

<Insert relevant variables> are proportional variables. Determine the proportional relationship that this graph suggests.

Process the data so that you can draw a straight-line graph. Plot and draw the straight-line graph.

Using information from the straight-line graph, for example, the gradient, find and state the mathematical relationship between < insert relevant variables>, based upon your investigation.

Producing a report

Write a report that **evaluates** and **explains** the results of your investigation. Your report should include:

- the dependent and independent variables of your investigation
- the techniques you used to improve the accuracy of your investigation
- an appropriately headed table which records **all** raw measurements using appropriate units and significant figures
- the non-linear graph you have drawn
- the proportional relationship that the non-linear graph suggests between the variables of length, <insert relevant variables>, for the investigation

- an appropriately headed table which records processed data using appropriate units and significant figures
- the linear graph you have drawn
- a conclusion that states the correct mathematical relationship between the <insert relevant variables>, based upon the linear graph
- a discussion that validates the conclusion.

You may validate your conclusion using one or more of the following:

- a mathematical comparison between the findings of your investigation and the physics theory stated
- identification of any variables that you controlled, an explanation of why they should be controlled and how you controlled them in your investigation
- a description of any difficulties encountered when making measurements and an explanation of how these difficulties were overcome
- a reason why there was a limit to the range of values you chose for the independent variable
- an identification of any unexpected results and a suggestion of how they could have been caused or the effect they had on the validity of the conclusion.

Additional information

Physics theory states that

$$T = 2\pi\sqrt{\frac{L}{g}}$$

<Insert equation for the relationship between the variables, example pendulum relationship given.>

Where *<insert the description of each variable in the stated equation, example for above relationship given>* *L* is the length of the string, T is the period of the oscillation, and g is the gravitational acceleration of the bob. The period, T, is the time for one complete oscillation.

Assessment schedule: Physics 2.1B Portfolio of Practical Reports

Evidence/Judgements for Achievement	Evidence/Judgements for Achievement with Merit	Evidence/Judgements for Achievement with Excellence
Student correctly: • identifies the independent <insert variable> and dependent <insert variable> variables • states or implies control of <insert the required control variable> (perceived control variable) • gathers at least 7 values of <insert variables> over a range of at least <insert expected values>, using the smallest scale division of the measuring instrument • plots points on a graph showing the relationship between the independent and the dependent variables, on axes labelled properly with quantities and units, and including a curve of best fit • describes the type of relationship that exists between <insert variable>, with correct proportionality of variables, <insert expected relationship>. Accept alternative non-linear graphs that lead to the correct relationship.	Student correctly and explicitly: • identifies the independent <insert variable>, dependent <insert variable>, and any control variables • gathers at least 7 values of <insert variable>, and <insert variable>, over a range of at least <insert expected values>, using the smallest scale division of the measuring instrument • uses techniques to improve the accuracy of the measured values, for example, repeats and averages three measurements for a particular distance, corrects for parallax by lining up eye with maximum amplitude, or adjusts the swing start position to produce a more suitably measurable range of times • transforms values of <insert variable and expected transformation>, with appropriate significant figures and units of <insert expected unit and number of significant figures> • plots non-linear and linear graphs showing the relationship between the independent and the dependent variables, on axes labelled properly with quantities and units, and including lines of best fit • calculates the gradient of the linear graph • derives the mathematical equation from graph, <insert expected equation> (value of gradient to be consistent with student data). • accept alternative linear graphs that lead to the correct equation.	Student correctly and explicitly: • identifies the independent <insert variable>, dependent <insert variable>, and control variables, and justifies their categorizations • gathers at least 7 values of <insert variable>, and <insert variable>, over a range of at least <insert expected values>, using the smallest scale division of the measuring instrument, and justifies their choice of range, for example, because of a limit to either end of the values chosen for the independent variable • describes the difficulties encountered when measuring, and links them to techniques used to improve the accuracy of the measured values, for example, notes that human reaction times can be slower than 1/10th of a second and therefore repeats and averages three time measurements for a particular distance to reduce reaction time error • transforms values of <insert variable and expected transformation>, with correct SI units and significant figures <insert expected unit and number of significant figures> (depending on the measuring instrument used) • plots non-linear and linear graphs showing the relationship between the independent and the dependent variables, on axes labelled properly with quantities and units, and including lines of best fit • calculates the gradient of the linear graph • derives the mathematical equation from graph, <insert expected equation> (value of gradient to

		be consistent with student data) • links the derived equation to physics ideas and provides reason for variance between theoretical and actual • reflects on the validity of their conclusion, with respect to physics ideas, unexpected outcomes, and/or effects of their particular experimental method.

Final grades will be decided using professional judgement based on a holistic examination of the evidence provided against the criteria in the Achievement Standard.